I have told you that in the origin of the spots the first disturbance is the formation of a few little openings probably by the advanced guard of the falling solid material. In a few days, by the continuous downpours, these develop into a spot. This spot is followed by a metallic prominence sending up the masses of gas at the rate, may be, of 250 miles a second—a rate Prof. Young has observed; and after that the faculæ appear. I throw that idea out because the greatest prominences are associated with the greatest spots; the spots begin the disturbance, and the energies radiate from the point where we first see the disturbance, which, I repeat, the spot begins.

We see, then, that on the sun the action will be almost just the opposite of what it is on the earth. We get first of all the descent of cooled matter on to the part of the sun where the disturbance begins.

Here we get ascent in consequence of greater heat outside. At the sun the greater heat inside the sun is liberated by the splash and explosion of spot-producing material.

Now, when the material falls in the way we have indicated, we shall get, if the idea is true, a considerable temperature in the region above the fall accompanying the return current in the shape of prominences. We may probably also get a current in the lower atmosphere set up towards the north and towards the south, and another thing we shall certainly get will be a tremendous brightening of this part of the solar atmosphere.

One of the great differences between one part of the solar atmosphere and another depends upon its temperature; so that you must imagine that the moment we get any great change in the temperature of any part of the atmosphere we must get a great change in its brilliancy, even in the higher regions: this may explain the streamers.

If there are these lower currents towards the poles there will probably be upper currents away from them which may in some way locate spot-forming material over the spot zones. On this subject, however, which, though one of the most important in solar physics, is one in which we see our way least clearly, I have not time to enter. J. NORMAN LOCKYER

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS

THE Institution of Mechanical Engineers held their annual meeting, under the presidency of Mr. Jeremiah Head, at the Theatre of the Institution of Civil Engineers, on the 6th and 7th inst.

Mr. T. B. Lightfoot read a paper on refrigerating and ice-making machinery and appliances. He commenced by describing a complete refrigerating machine as an apparatus by which heat is abstracted, in combination either with some system for renewing the heat-absorbing agent, or, as is more usually the case, with a contrivance by which the abstracted heat is rejected and the agent is restored to a condition in which it can again be employed for cooling-purposes.

The first method by which heat is abstracted by the rapid fusion of a solid is probably the oldest. It depends upon the very strong tendency of mixtures of certain salts with water or acids, and of some salts with ice—which form liquids whose freezing-points are below the original temperatures of the mixtures—to pass into the liquid form; heat is absorbed more quickly than it can be supplied from without, and the temperature consequently falls. This method has been mainly employed for domestic and laboratory purposes.

When heat is abstracted by the second method, that is, by the evaporation of a more or less volatile liquid, other things being equal, the liquid with the highest latent heat will be the best refrigerant, because for a given abstraction of heat, the least weight of liquid will be required, and therefore the power expended in working the machine will be the least. There are four different kinds of processes employed.

The first, in which the refrigerating agent is rejected with the heat it has acquired, is generally known as the vacuum process. Water, the only agent cheap enough to be employed, must be reduced to a pressure below 0·089 lb. per square inch, which is the pressure of water-vapour at the temperature of melting ice. A vacuum-pump is employed, combined with a vessel containing strong sulphuric acid, for absorbing the vapour from the air drawn over, and so assisting the pump. Lately an improvement has been effected in this process by the employment of a pump with two cylinders and intermediate condenser, the water being admitted to the ice-forming vessels in fine streams, so as to offer a large surface for evaporation. The second, or compression-process, is used with liquids whose vapours condense under pressure at ordinary temperatures. The first apparatus employed, though in some respects crude, is yet the parent of all compression-machines used at the present time, the improvements being generally in matters of constructive detail. The water to be frozen was placed in a jacketed copper pan, the jacket being partially filled with the volatile liquid, and carefully protected on the outside with a covering of non-conducting material. A pump drew off the vapour from the jacket, and delivered it compressed into a worm, around which cooling water was circulated, the pressure being such as to cause liquefaction. The liquid collected at the bottom of the worm, and returned to the jacket through a pipe, to be again evaporated. Most modern machines comprise a refrigerator, a water-jacketed pump, a condenser, and ice-making tanks containing moulds or cells, around which brine cooled to a low temperature in the refrigerator is circulated by means of a pump. The working pressure in the refrigerator depends upon the reduction in temperature desired, the higher the pressure the greater being the work that can be got out of any given capacity of pump. The liquefying pressure in the condenser depends on the temperature of the cooling water, and on the quantity that is passed through in relation to the quantity of heat carried away; this pressure determines the mechanical work to be expended. To produce transparent ice, the water has to be agitated during freezing, so as to allow the air to escape. Various refrigerating media have been used, such as ether, sulphur dioxide, and anhydrous ammonia. The third is known as the absorption process: the principle employed is chemical or physical rather than mechanical, and depends on the fact that many vapours of low boiling-point are readily absorbed by water, but can be separated again by the application of heat to the mixed liquid. Taking advantage of the fact that two vapours, when mixed, can be separated by means of fractional condensation, an absorption machine has been brought out in which the distillate was very nearly anhydrous. Ordinary liquid ammonia of commerce was heated, and a mixed vapour of ammonia and water was driven off. By means of vessels termed the analyser and the rectifier, the bulk of the water was condensed at a comparatively high temperature and run back to the generator, while the ammonia passed into a condenser, and there assumed a liquid form. The nearly anhydrous liquid was then evaporated in the refrigerator in the ordinary way; but, instead of the vapour being drawn off by a pump, it was absorbed by cold water or weak liquor in a vessel called an absorber, which was in communication with the refrigerator, and the strong liquor thus formed was pumped back to the generator and used over again. In the fourth, which is known as the binary absorption system, liquefaction of the refrigerating agent is brought about partly by mechanical compression and partly by absorption; or else the refrigerating agent itself is a compound of two liquids, one of which liquefies at a comparatively low pressure, and then takes the other into solution by absorption. An interesting application of this system has been recently made by Raoul Pictet, who found that, by combining carbon dioxide and sulphur dioxide, he could obtain a liquid whose vapour-tensions were not only very much less that those of carbon dioxide, but were actually below those of pure sulphur dioxide at temperatures above 78° Fahr. This very remarkable and unlooked-for result may open up the way for greater economy in ice-production.

The third method is that in which machinery is used by which gas is compressed, partially cooled while under compression, and further cooled by subsequent expansion in the performance of work, the cooled gas being afterwards used for abstracting heat. This method has been much employed of late years, under the title of "Cold-air machines" for the preservation of meat and other perishable food. The author has designed machinery of this class, in which a weight of 1000 lbs. of air per hour can be reduced from 60° above to 80° below zero Fahrenheit, with cooling water at 60° F., with the expenditure of about 18 indicated horse-power. The air after being compressed in the compresser passes to the coolers, which consist of a couple of vessels containing tubes, through which water is circulated by a pump. The compressed air passes through one cooler and returns through the second, being cooled to within 5° or 6° of the initial temperature of the cooling water, which circulates in a direction opposite to that of the air. From the coolers the air passes to

the expansion cylinder, and after performing work upon the piston, and returning about 60 per cent. of the power expended in its compression, it is exhausted, having been cooled down from 70° above to 90° below zero Fahr. Besides its application to the importation of dead meat, live cattle, &c., an interesting application was made last year in the construction of a tunnel through a hill in Stockholm, in the excavation of which, some running ground was met with, consisting of gravel mixed with clay and water, which it was determined to freeze. The innermost end of the tunnel next the face was formed into a freezing-chamber by means of partition walls, which were made of a double layer of wood filled in between with charcoal. The temperature of the freezing-chamber was generally from 6° to 15° below zero Fahr. after twelve hours' running, but soon rose to freezing-point when the men began to work. The tunnel was driven through its length of 80 feet with entire success, the daily progress averaging about 1 foot.

A paper on the distribution of the wheel-load in cycles, illustrated by means of fifty-six figures, was read by Mr. J. Alfred Griffiths. The author gives the following five points of efficiency as applying to cycles generally, viz. reduction of dead weight by the avoidance of very large wheels and of heavy or purely ornamental or unnecessary framing; reduction of resistance by avoidance of very small wheels, and by employment of the best designs in bearings and in driving-mechanism for the diminution of internal friction; perfection of load distribution by entire avoidance of wheels that neither transmit motive-power nor assist the steering, and by concentration of the load on the driving-wheels and reduction of that on the steering-wheels; stability when at rest and when in motion on the straight and round curves, when on a smooth surface and also on a rough and lumpy road, and when the brake is applied either suddenly or gradually; arrangement of load and driving-mechanism so that the distribution of the wheel-load shall be as good on rising or falling gradients as on a level. Tables of dimensions and distribution of wheel-load were appended.

A paper on the raising of the wrecked steamship *Peer of the Realm*, which was effected by the platforming method, and without the aid of divers for any part of the operation, was read by Mr. T. W. Wailes, of Cardiff.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The Council of Somerville Hall have decided to build additional rooms for twenty students. Two Entrance Scholarships of 35*l*. and 40*l*. a year are offered for competition on May 25.

SCIENTIFIC SERIALS

American Journal of Science, March.—Examination of Dr. Croll's hypothesis of geological climates, by Dr. A. Woeikof. The author subjects Dr. Croll's theories to a searching criticism, traversing all his fundamental principles. The statement that the ocean must stand at a higher *mean* temperature than the land is shown to be quite erroneous, the oceans which receive cold currents from Polar seas, and even seas like the Mediterranean and Red Sea, which receive no such currents, having a mean temperature considerably lower than the continents. His whole system of estimating temperature breaks down when seriously tested, the errors being enormous, in some cases upwards of 100° F., or greater than the difference of annual temperature between the equator and the North Pole. His hypotheses, although brilliant and fascinating, cannot be accepted, the main points on which they rest being opposed to the most certain teachings of meteorology, and the whole fabric in its explanation of glaciation and geological climates generally being entirely fallacious.—Tendril movements in *Cucurbita maxima* and *C. Pepo* (concluded), by D. P. Penhallow. The author concludes generally that growth is promoted by an increase of temperature and humidity, but may be retarded by an increase of temperature when other conditions are unfavourable. It is also retarded by excessive transpiration, while the conditions favourable to growth, arising from temperature and humidity, may cause greater growth during the day in opposition to the retarding influence of light. Movements of tendrils and terminal buds, being phenomena of growth, are modified by whatever variations of condition affect growth.—Note on a method of measuring the surface-tension of liquids, by W. F. Magie. It is shown that Poisson's formula determining approximately the height of a large liquid drop standing on a level plate holds good, without any change, for a bubble of air formed in a liquid under a level plate.—Remarks on W. B. Rogers's "Geology of the Virginias" (continued), by J. L. and H. D. Campbell. In this concluding paper the authors deal with the most salient points in the higher formations of the geological system of Virginia and West Virginia. Their remarks, based mainly on personal observation, are intended to be supplementary to Mr. Rogers's comprehensive treatise on the geology of this region.—Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species, by D. W. Langdon. An important result of these observations is the establishment of the relation of the Jackson beds to the Orbitoides limestone and marl beds of Byram Station. The new species, which will be figured in the forthcoming Report of the Geological Survey of Alabama are: *Verticordia eocensis*, apparently the first Verticordia described from this epoch; and *Bulla* (*Haminea*) *aldrichi*, an elongate oval shell resembling *Bulla glaphyra*, Desh.—On the area of Upper Silurian rocks near Cornwall Station, Eastern Central Orange County, New York, by Nelson H. Darton. The paper contains a careful study of the Towsend Iron Mine district and vicinity, where a small mass of Lower Helderberg limestone has been protected from the general denudation by a firm backing of coarse strongly cemented sandstones. The whole forms a ridge running just west of Cornwall Station, its more prominent geological features being shown on the accompanying map.

Rivista Scientifico-Industriale, March 15.—On the crepuscular lights that followed the Krakatão eruption, by Prof. Alessandro Sandrucci. The author surveys with Hirn the various theories propounded to explain this phenomenon, and rejects them all as inadequate, or else based on impossible assumptions. He concludes that for the present the after-glows must be classed with the numerous effects the causes of which have not yet been fathomed.—On the origin of atmospheric electricity, by Prof. Luigi Palmieri. A simple experiment is described, by which it is clearly shown that positive electricity is generated by the moisture of the air, when it becomes condensed by a lowering of the temperature. This conclusion is reconciled with the theory recently advanced by Prof. Edlund, of Stockholm, who argues that the electricity of the air is derived from the earth by the unipolar induction of terrestrial magnetism, while its return to the earth is caused by the condensation of the aqueous vapours, and especially by their conversion into the fluid state.

Rendiconti del Reale Istituto Lombardo, April 1.—Reptiles of the Orta-Kenei district, Adrianople, by Prof. F. Sordelli. This is an account of the collection recently made at the southern foot of the Balkan Range by the Cavaliere Luigi de Magistris, and by him presented to the Civic Museum of Milan. Of over twelve species of reptiles three only are found in the Po Valley, all the rest being of an essentially Eastern character, with a range extending from the Balkan Peninsula to the Iranian Plateau.—Note on a fundamental theorem in the theory of the functions of a complex variable quantity, by G. Morera.—Stratigraphic observations in the province of Avellino, by Prof. T. Taramelli. The paper contains a systematic study of the stratified rocks exposed by the cuttings of the Avellino and Santa-Venere line of railway, and ranging through the whole series from the Lower Chalk through the Eocene, Miocene, and Pliocene, to the more recent Quaternary formations.—Account of a rare and interesting ornithological specimen, by Prof. Pietro Pavesi. The author describes a fine specimen of *Bernicla leucopsis*, Bechst., recently shot at Corana in the Po Valley, and now preserved in the Civic Museum of Pavia.—On the rational curves in a linear space to any number of dimensions, by A. Brambilla.—Meteorological observations made at the Brera Observatory, Milan, during the month of March.

SOCIETIES AND ACADEMIES

LONDON

Zoological Society, May 4.—Prof. W. H. Flower, LL.D., F.R.S., President, in the chair.—Mr. E. L. Layard, F.Z.S., exhibited a fine example of a rare Beetle of the family Cerambycidæ (*Macrotoma heros*), obtained in the Fiji Islands; and a series of specimens of shells of the genus Bulimus from New Caledonia and the adjacent islands.—A letter was read from Mr. F. W. Styan, F.Z.S., relating to some Chinese ani-